hearing aid users, car owners, hospitals, airports, medical equipment suppliers, consumer protection agencies, etc.. I also wish to advice you that it is considered inaccurate for Wireless Communications Council to single out GSM as a potential interferer, as all analogue and digital radiotransmission standards can influence the function of electronic devices including, but not limited to AM, FM, AMPS, CDMA & D-AMPS. It must also be recognized that many digital radio transmitting systems, including D-AMPS, utilize the exact same radio access method as GSM, Time Division Multiple Access (TDMA).

As I have a background not only as a scientific telecommunications research expert, but also as a development manager for the hearing aid industry, I am consistently advising both industries in the development of new modulation technologies and EMC compatibility test methods. A complete copy of my research can be obtained upon request at facsimile number + 45 45 76 99 83.

With copy of letter to:
The Honorable Senator Trent Lott
The Honorable Senator Bob Packwood
Baker & Hostetler, Mr. Guy Vander Jagt

Sincerely,

Ole Mørk Lauridsen
Corporate Director R&D
Professor, MSc. E.E.

S0326tst.ske

Headquarter:
Kanalvejen 16
8000 Århus C
Denmark
Tel.: + 45 89 33 77 77
Fax: + 45 89 33 81 33

Lyngsø Allé 2
2970 Hørsholm
Denmark
Tel.: + 45 45 76 64 44
Fax: + 45 45 76 99 83

Tele Danmark A/S
Århus
Company Reg. No. 183.447
Telex 64444 tdk dk

DeTeMobil

Deutsche Telekom MobilNet GmbH
Postfach 300463, 53184 Bonn

Thomas E. Wheeler
President and CEO
Postfach Industry Association
1250 Connecticut AVE, NW
Suite 200

Washington DC 20036

Ansprechpartner Stephan Wenig, T24-6
Direkt Tel: 06151/852-725, Fax: 06151/852-728
Datum 29. Juni 1995
Thema

Dear Mr. Wheeler,

I understand that the carriers and manufacturers of the wireless industry in North America are sponsoring research at the University of Oklahoma, Center for the Study of Wireless Electromagnetic Compatibility on the potential for interference from various digital technologies to hearing instruments.

Although the digital technologies under consideration for deployment in the United States differ somewhat from the technology we have deployed, we are pleased to provide the following information on our operating experience with GSM technology in Germany.

We have been providing GSM service in the 900 Mhz frequency band since July 1992. We currently provide service to 1.1 mill. customers. To date, we have received no reports of interference to hearing aids form our GSM phones.

I hope this information is useful as you evaluate the nature of interaction between various digital technologies and hearing instruments. Please let me know if we can be of any additional assistance.

Sincerely

ppa. R. Mahler

R. Mahler

Hausanschrift DeTeMobil Deutsche Telekom MobilNet GmbH
Postanschrift Oberkasseler Straße 3, 53227 Bonn
Telekontakte Postfach 300463, 53184 Bonn
Geschäftsführung Telefon (0228) 936-0, Telefax: (0228) 936-9950
Aufsichtsrat Dr. Lothar Hunzel (Vors.), Heinz Fummler, Horst Joachim Grimm, Klaus Hummel, Klaus Wedenberger, Werner Penz (Betriebsr.)
Bankverbindungen Dr. Wilhelm Pfannkuch (Vors.)
Eintrag Dresdner Bank Bonn, Konto Nr. 2 052 240 00, BLZ 370 800 40, Postbank AG Essen, Konto Nr. 10080-437, BLZ 360 100 43
Umsatzsteuer Nr. Amtsgericht Bonn, HRB 96 19
DE 122265872

TELE
Telecom Finland

NMT-GSM
TELEMATKAPUHELUT

Thomas E. Wheeler
President and CEO
Cellular Telecommunications Industry Association
1250 Connecticut Ave, NW
Suite 200
Washington DC 20036

Dear Mr. Wheeler,

I understand that the carriers and manufacturers of the wireless industry in North America are sponsoring research at the University of Oklahoma Center for the Study of Wireless Electromagnetic Compatibility on the potential for interference from various digital technologies to hearing instruments.

Although the digital technologies under consideration for deployment in the United States differ somewhat from the technology we have deployed, we are pleased to provide the following information on our operating experience with GSM technology in Finland.

We have been providing GSM service in the 900 MHz frequency band since June 1991 (commercially since June 1992). We currently provide service to 130 000 GSM customers. To date, we have received less than 20 reports of interference to hearing aids from our GSM phones. Almost all the reports of interference were received during the first year of commercial operation. In fact, we have subscribers who are hearing aid wearers and are quite pleased with their GSM phones.

I hope this information is useful as you evaluate the nature of interaction between various digital technologies and hearing instruments. Please let me know if we can be of any additional assistance.

Mr. Olavi Kolstinen
Deputy Director
NMT-GSM -section
Mobile Telephone Services, Telecom Finland
P.O. Box 98
FIN-00511 Helsinki
tel. +358 20401, fax. +358 2040 5312

Telenor Mobil

Thomas E. Wheeler
President and CEO
Cellular Telecommunications Industry Association
1250 Connecticut Ave, NW
Suite 200
Washington DC 20036

Date
1995-06-29

Our reference
Petter Bliksrud

INTERFERENCE FROM CELLULAR EQUIPMENT

Dear Mr. Wheeler,

I understand that the carriers and manufacturers of the wireless industry in North America are sponsoring research at the Univerity of Oklahoma Center for the Study og Wireless Electromagnetic Compability on the potential for interference from various digital technologies to hearing instruments.

Although the digital technologies under consideration for deployment in the United States differ somwhat from the technology we have deployed, we are pleased to provide the following information on our operating experience with GSM technology in Norway.

We have been providing GSM service in the 900 Mhz frequency band since May 1993. We currently provide service to well over 100.000 customers. To date, we have received no specific reports of interference to hearing aids from our GSM phones. In fact, we have subscribers who are hearing aid wearers and are quite pleased with their GSM phones.

I hope this information is useful as you evaluate the nature of interaction between various digital technologies and hearing instruments. Please let me know if we can be of any additional assistance.

Yours faithfully
for Telenor Mobil AS

Petter Bliksrud
R & D manager

Telenor Mobil AS

Office:
Pilestredet 35
N-0166 OSLO

Postal address:
Postboks 6706 St.
Olavs plass
N-0130 OSLO

Telephone:
+47 22 03 03 00
Telefax:
+47 22 03 03 99

Head Office:
Pilestredet 35
0166 Oslo
Enterprise No.:
NO 984 054 858 MVA

William L. Keever

Mitglied der Geschäftsführung
Mannesmann Mobilfunk GmbH

Mr. Thomas E. Wheeler
President and CEO
Cellular Telecommunications Industry Association
1250 Connecticut Avenue, NW
Suite 200
Washington DC 20036
USA

28 June 1995

Dear Mr. Wheeler,

I understand that the carriers and manufacturers of the wireless industry in Northern America are sponsoring research at the University of Oklahoma Centre for the Study of Wireless Electromagnetic Compatibility on the potential for interference from various digital technologies to hearing instruments.

Although the digital technologies under consideration for deployment in the United States differ somewhat from the technology we have deployed, we are pleased to provide the following information on our operating experience with GSM technology in Germany.

We have been providing GSM service in the 900 MHz frequency band since July 1992. We currently provide service to more than 1 million customers. To date, we have only received irregularly a few reports of interference to hearing aids caused by our GSM phones. These reports have all been handled in a very straightforward manner.

I hope this information is useful as you evaluate the nature of interaction between various digital technologies and hearing instruments. Please let me know if we can be of any additional assistance.

Yours sincerely,

W. L. Keever

Am Seestern 1 · D 40547 Düsseldorf · Postfach 40 04 48 Düsseldorf · Telefon 02 11/ 533-2701

St James Court
Great Park Road
Almondsbury Park
Bradley Stoke
Bristol
BS12 4QJ
Tel 01454 624600
Fax 01454 618501

Ref: 0321/lmh/ri

28 June 1995

Thomas E Wheeler, Esq
President and CEO
Cellular Telecommunications Industry Association
1250 Connecticut Ave, NW
Suite 200
Washington DC 20036

Dear Mr Wheeler

I understand that the carriers and manufacturers of the wireless industry in North America are sponsoring research at the University of Oklahoma Centre for the Study of Wireless Electromagnetic compatibility on the potential for interference from various digital technologies to hearing instruments.

Although the digital technologies under consideration for deployment in the United States differ somewhat from the technology we have deployed, we are pleased to provide the following information on our operating experience with GSM technology in the UK.

We have been providing GSM service in the 1800 Mhz frequency band since April 1994. We currently provide service to around 200,000 customers. To date, we have received very few reports of interference to hearing aids from our GSM phones. In fact we have subscribers who are hearing aid wearers and are quite pleased with their GSM phones.

I hope this information is useful as you evaluate the nature of interaction between various digital technologies and hearing instruments. Please let me know if we can be of any additional assistance.

Yours sincerely

Dr Colin Tucker
Group Director of Operations

260 Bath Road
SLOUGH
Berkshire
SL1 4DX
Telephone 01753 565000
Fax 01753 565010

Mr Thomas E Wheeler
President and CEO
Cellular Telecommunications Industry Association
1250 Connecticut Ave, NW
Suite 200
Washington DC 20036

6 July 1995

Dear Mr Wheeler

I understand that the carriers and manufacturers of the wireless industry in North America are sponsoring research at the University of Oklahoma Centre for the Study of Wireless Electromagnetic Compatibility on the potential for interference from various digital technologies to hearing instruments.

Although the digital technologies under consideration for deployment in the United States differ somewhat from the technology we have deployed, we are pleased to provide the following information on our operating experience with GSM technology in the UK.

We have been providing GSM service in the 900 Mhz, frequency band since 1993 . We currently provide service to 65,000 customers. To date, we have received no reports of interference to hearing aids from our GSM phones and only one enquiry. In fact, we have subscribers who are hearing aid wearers and are quite pleased with their GSM phones.

I hope this information is useful as you evaluate the nature of interaction between various digital technologies and hearing instruments. Please let me know if we can be of any additional assistance.

Yours sincerely

Mike Short
Director

CF/627/1

ETSI TECHNICAL REPORT

ETR 108

February 1994

Source: ETSI TC-SMG

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European digital cellular telecommunications system (Phase 2); GSM Electro Magnetic Compatibility (EMC) considerations (GSM 05.90)

ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: 06921 Sophia Antipolis Cedex - FRANCE
Office address: Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE

Tel.: + 33 92 94 42 00 - Fax: + 33 93 65 47 16

Contents

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Foreword

This ETSI Technical Report (ETR) has been produced by the Special Mobile Group (SMG) Technical Committee (TC) of the European Telecommunications Standards Institute (ETSI).

This ETR summarises the work which has been conducted, mainly in the UK, to investigate the effect of wanted radio frequency transmissions from GSM Mobile Stations (MS) and Base Transceiver Stations (BTS) within the European digital cellular telecommunications system (phase 2) on other equipment.

This ETR is an informative document resulting from SMG studies which are related to the European digital cellular telecommunications system (phase 2). This ETR is used to publish material which is of an informative nature, relating to the use or the application of ETSs and is not suitable for formal adoption as an ETS.

This ETR corresponds to GSM technical specification, GSM 05.90 version 4.2.1.

The specification from which this ETR has been derived was originally based on CEPT documentation, hence the presentation of this ETR may not be entirely in accordance with the ETSI/PNE rules.

Reference is made within this ETR to GSM Technical Specifications (GSM-TS) (NOTE).

NOTE: TC-SMG has produced documents which give the technical specifications for the implementation of the European digital cellular telecommunications system. Historically, these documents have been identified as GSM Technical Specifications (GSM-TS). These TSs may have subsequently become I-ETSs (Phase 1), or ETSs (Phase 2), whilst others may become ETSI Technical Reports (ETRs). GSM-TSs are, for editorial reasons, still referred to in current GSM ETSs.

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1.1. Scope

A considerable amount of work has been conducted, mainly in the UK, to investigate the effect of wanted radio frequency transmissions from GSM MS and BTS on other equipment. This report aims to summarise this work and to look at the implications for GSM. Since GSM EMC considerations extend outside the GSM arena, it is thought essential that GSM considers the implications of EMC and produces this report.

1.2 References

This ETR incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETR only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

[1] 89/336/EEC: "Council Directive on the approximation of the laws of the Member States relating to electromagnetic compatibility".

[2] EN 50082-1 (1992): "Electromagnetic compatibility - Generic immunity standard. Part 1: Residential, commercial and light industry".

[3] IEC 801-3, (1984): "Immunity to radiated, radio frequency, electromagnetic fields"

[4] GSM 01.04 (ETR 100): "European digital cellular telecommunication system (Phase 2); Definitions, abbreviations and acronyms".

[5] DTI/RA: "A summarised report on measurement techniques used to investigate potential interference from new digital systems"

[6] INIRC (1988): "Guidelines on limits of exposure to radiofrequency electromagnetic fields in the frequency range 100 kHz to 300 GHz"

[7] NRPB (1989): "Guidance as to restrictions on exposures to time varying electromagnetic fields and the 1988 recommendations of the Internation Non-Ionizing Radiation Committee"

[8] IEEE C95.1 (1991): "IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 4 kHz to 300 GHz"

[9] Draft DIN VDE 0848 Part 2 (1991): "Safety in electromagnetic fields; protection of persons in the frequency range from 30 kHz to 300 GHz"

2. Information available

A number of European organisations have conducted extensive investigations into GSM EMC. These investigations looked at the potential of a GSM transmission to interfere with a wide range of electrical apparatus. Having conducted both objective and subjective investigations, it was discovered that personal audio equipment (e.g. Walkmans) and hearing aids were most susceptible and most likely to be in close proximity to GSM apparatus.

Of these two types of apparatus, hearing aids were considered the greatest potential problem and thus a considerable amount of modelling work was conducted in order to assess the likely incidence of interference in various scenarios.

Interference with pace-makers was considered of utmost seriousness and consequently tests were made to investigate the possibility of interfering with certain types.

3. Cause of potential EMC interference

The source of GSM interference is the 100% amplitude modulated RF envelope introduced by burst transmission necessary for TDMA. Audio apparatus having some non-linear component able to demodulate this AM envelope will be subject to interference in the audio pass-band since the frame and burst rates for GSM are 220 Hz and 1.7 kHz.

Another source of interference is the DTX (Discontinuous Transmission) mode of operation in GSM. In the DTX mode there are two signal components with much lower frequencies than the normal GSM transmission: a component with a frequency of 2.1 Hz corresponding to the transmission of the 8 timeslots of the SID (Signal Descriptor) message block, and another with a frequency of 8.3 Hz corresponding to the repetition rate of SACCH.

4. Laboratory results

4.1 Hearing aids

Objective laboratory results from the United Kingdom, Department of Trade and Industry, Radiocommunications Agency (DTI/RA) [5] showed that a typical "behind the ear" hearing aid in normal (amplifying) mode was susceptible to peak GSM field intensities of;

- between 10 V/m and 17 V/m in order to produce the same audio power as speech, 0.5 m in front of the hearing aid, and
- between 5 V/m and 8.5 V/m to produce "audible, slightly annoying" interference.

It was noted that the group of hearing aids tested showed a 4 dB spread in susceptibility in the normal mode and a 13 dB spread in susceptibility in the inductive loop mode.

Subjective investigation conducted at BTRL with the hearing aid worn by the user showed that "audible, slightly annoying" interference was perceived when subject to a peak field intensity varying between 10 V/m and 4 V/m depending upon the orientation of the head. This was modelled by a peak field intensity of 10 V/m for a 270^{0} arc and 4 V/m for the 90^{0} arc not shielded by the head inferring an 8 dB attenuation provided by the head. This directional susceptibility corresponds to an average of 6.6 V/m and thus agrees with the DTI/RA objective results.

These results were subsequently used for modelling activities to assess the consequences of this susceptibility in various scenarios. It should be noted that the susceptibility without head attenuation used in the model (4 V/m) is somewhat worse than the DTI measurements (5 V/m - 8.5 V/m) and thus the modelling results will be very much worst case.

It was found that metallising the hearing aid case reduced the susceptibility with no head attenuation from 4 V/m to 12 V/m (10 dB).

Laboratory measurements have been carried out also in Australia by Telecom Research Laboratories and National Acoustic Laboratories [Annex F]. In these measurements the field straight level causing useful "annoyance" threshold level of 10 dB above the noise floor of the hearing aids was measured and then compared to measured field strengh of 2 W and 8 W GSM MS to determine the distances where the threshold levels can be expected. Both behind-the-ear and in-the-ear type hearing aids were measured, the former ones both with microphone input and telecoil input. The results are shown below.

Hearing aid type	Field strenght for noticable interference	Distance for noticable interference	
		2 W MS	8 W MS
Behind the ear, microphone input	0.7 - 3.1 V/m	2.0 - 10 m	3.5 - 20 m
Behind the ear, telecoil input	0.4 - 4.9 V/m	1.5 - 20 m	2.5 - 40 m
In the ear	4.9 - 32.3 V/m	0.2 - 0.8 m	0.4 - 1.5 m

Table 1. Field strenght and safety distances for noticeable interference.

Note 1: The distances in Table 1 can not be compared directly with those in Table 2 because Table 1 distances are approximate real-life distances whereas Table 2 is based on theory.

In Denmark a study initiated by the Danish ministery of communications has been carried out recently. The results of the study are in a report "Interference to hearing aids caused by GSM mobile telephones". Following are the main conclusions of the report.

- so far there have not been many actual examples of interference but it must be foreseen that in 3 - 4 years there will be frequent reports of interference to hearing aids occasioned by GSM mobiles

- it is anticipated that existing hearing aids will be replaced by new models with generally greater immunity to GSM signals; in any event, in 5 - 7 years the risk of interference should have diminished significantly

- solutions to decrease the amount of interference based on GSM system will either have a highly limited effect (transmitter power regulation) or will be financially unfeasible (cell size optimisation)

- solutions based on design changes to hearing aids will generally be possible and must offer immunity against signal strengths of up to 10 V/m; some hearing aids used today already satisfy requirements and future models will be able to be so constructed as to meet them too; designing a new hearing aid with the requisite level of immunity would increase prices approx. DKK 100 per unit, which is a 4 - 7 % increase to a current price of a hearing aid

4.2 Cardiac pace-makers

Work was carried out by CSELT Italy to investigate the effects of GSM type burst structure on cardiac pace-makers [Annex D]. Unipolar and bipolar types from one manufacturer were tested. The results show that, although it was possible to interfere with pace-maker operation in free space, it was not possible, with the equipment power used, to interfere with operation when the pace-maker, leads and electrodes were placed in a phantom simulating realistic use in the human body. The equivalent maximum field strength used for this test would not normally be exceeded at further than 0.5 m away from any allowed GSM transmitter except the maximum power base station. For information the field strength required to defeat the pace-maker in free space was in excess of 40 V/m for the most sensitive class of pace-maker.

As there does not appear to be a problem with defeating of pace-maker operation by a normal GSM signal, the remainder of the work done by GSM, and thus the remainder of this report, is restricted to scenarios for audible interference with hearing aids.

4.3 Domestic Equipment

Tests carried out by various laboratories and collected together by the Radio Technology Laboratory (RTL) of the Radiocommunications Agency [Annex E] show that for a limited number of devices under test the cassette decks, television receivers and portable radios/cassette players etc. are the most susceptible domestic equipment with the mean field intensities causing "visible/audible, but not annoying" interference being 2.9, 4.0, and 5.6 V/m, respectively. For example for 8 W MS the field strenght of 4 V/m will be found at distances less than 5 m (worst case assuming 100 % efficiency and free space path loss) as can be seen in Table 1.

This means that in practice, due to building attenuation etc., interference will not occur unless the transmitter and the victim equipment are in the same room. This is likely to occur if the GSM terminal is transportable (8 W output power for instance).

Studies on the GSM interference to the fixed network telephone equipment have been carried out in France, Norway, U.K. and Italy [Annex G]. All the studies highlight the fact that due to the lack of an international immunity standard to the fixed network telephone equipment the interference problem varies from country to country depending on the national immunity standards. The study carried out in France summarises that no telephone analog equipment or audio terminal can comply with a 10 V/m GSM type field strength, and half of the telephone sets tested did comply with the 3 V/m immunity level, both results derived with a selected performance criteria of -50 dBmop/600 Ohms in transmit direction and 50 dBA on receive direction. Regarding the maximum distances for potential interference the study gives the distances of 10 meters for 8 W GSM terminal and 5 meters for 2 W GSM terminal. The U.K. study tests the fixed network telephones and PBX equipment at 3 V/m and 10 V/m field strengths and concludes that in the U.K. the vast majority of telephones and telephone equipment is not susceptible at even 10 V/m. Hence, due to the immunity standard for fixed telephones the interference from GSM terminals is not considered as a major problem in U.K.. In the Norwegian study it is summarised that with a 40 dB S/N ratio as a quality limit and with 10 W GSM transmitter 10 m away from a telephone, half of the telephones tested pass the test. Also, the study highlights the very large difference in the immunities of the fixed telephones, the immunities calculated in field strength being from 12.3 V/m to 0.8 V/m, with the same quality limit of 40 dB S/N ratio. The Italian study uses the same pass criteria as the French one and concludes that out of the tested fixed telephones, only an RF-shielded model and another with a very compact structure resulted complying with immunity requirements up to 6 V/m GSM field strength (that is 0.8 W GSM emission at 1 m distance), while some models did not even comply with 3 V/m (i.e. 0.8 W GSM emission at 2 m distance).

5. Modelling results

A wide range of scenarios were modelled [Annexes A and B] to include the possible interference to hearing aid users from base stations, mobiles and handportables. Not surprisingly, by far the highest incidence of interference was caused in crowded urban environments where hearing aids and handportable transceivers are likely to be in closest proximity.

It was found that a hearing aid user would experience 3 seconds of interference every 8 minutes whilst walking on a London street and would be subject to a 2.4% probability of interference whilst travelling on a commuter train for a GSM system occupying 2 x 25 MHz. Further results showed that with 1% of the train passengers using GSM transmitters (0.1% previously) and an average susceptibility of 4 V/m, the probability of interference was 5%. These modelling results were based on a small sample of hearing aids with immunities in the region of 3 V/m. More recent measurements have shown that some hearing aids, in particular the in-the-ear aids, have immunities up to 30 V/m (see Annex F). This would reduce these probabilities by a factor of 100.

It should be noted that the modelling work is based on free space path loses. The effect of, for example, people in a crowded train has not been measured, but in general it is expected that the presence of people or objects between the MS and the hearing aid will be to reduce the interference in most cases.

It should be noted that all the scenarios examined assumed the hearing aid was active all the time. Clearly, there will be instances where the user will switch off the aid when not required to communicate.

A further modelling exercise indicated that it was unlikely that a hearing aid user will be able to use GSM handportable terminals due to the interference effects.

6. Solutions

The generic immunity standard, EN 50082-1, produced by CENELEC, calls for immunity to RF electromagnetic fields of 3 V/m. This work has shown that current hearing aids have immunities close to this proposed level and that a handportable GSM transmitter is likely to present a field strength greater than this at regular intervals in a crowded environment and thus cause interference to the hearing aid user [Annex C]. The actual field strength from a dipole, as calculated from IEC 801-3:1984, is shown in Table 2 (the values are independent of frequency).

Peak transmit power (Watts)	GSM MS power class	Peak field strength (V/m)		
		1m	2m	5m
0.8	5	6.3	3.1	1.3
2	4	9.9	5.0	2.0
5	3	15.7	7.8	3.1
8	2	19.8	9.9	4.0
	DCS 1800 MS power class			
0.25	2	3.5	1.8	0.7
1	1	7.0	3.5	1.4

Table 2: Close proximity field strengths

A solution to this potential problem could be achieved by a combination of increased hearing aid immunity and constraints placed on the GSM system in urban environments.

Due to the likely peak field strengths that will be experienced from GSM transmitters in crowded urban areas, it is proposed that the immunity of future body worn apparatus, such as hearing aids, should be increased to 10 V/m since this has been found to significantly reduce the probability of GSM interference (this 10 V/m figure is derived from considerations of frequencies around 900 MHz and may not be applicable to frequencies significantly higher or lower than 900 MHz). Further to this, a number of simple constraints for urban GSM system design should be adhered to:-

- dynamic power control to be implemented at the MS such that only the minimum required transmit power is used at all times (BS interference was shown not to be a problem)
- urban cell sizes limited to reduce required transmit powers
- discontinuous transmission (DTX) to be implemented where possible
- GSM base site and mobile pay phone (e.g. on train) transmit antennas should not be located in close proximity to electrical apparatus likely to be susceptible to this type of interference.

It is assumed that DTX will provide a reduced interference potential although this has not been verified.

7. Non-ionizing radiation

The major effect from exposure to RF radiation is due to the transfer of energy from the electromagnetic field to biological tissues, resulting in a temperature rise. The heating is caused by the fact that centres of negative and positive charges do not coincide in many biological tissues including water. The charge separation causes molecules to oscillate in a microwave field, generating heat.

Guideline levels for exposure to non-ionizing RF radiation have been published by many organisations including Non-Ionizing Radio Committee (INIRC) [6], the UK National Radiological Protection Board (NRPB) [7], the Institute of Electrical and Electronics Engineers (IEEE) [8] and the German Electrotechnical Comission of DIN and VDE (DKE) [9]. Table 3 shows the levels of power density given by each organisation which they believe will ensure that no health hazard exists. Some of the figures given in Table 3 are under review by the above organisations.

Organisation	Safety level at 900 MHz (W/m^2)	Safety level a 1.8 GHz (W/m^2)
NRPB	22.5	45
INIRC	4.5	9
IEEE	6.0	12
DKE	4.5	9

Table 3. Power density safety values

The differences in the figures depend on the time how long the victim is assumed to be exposed by the radiation, and is for the most stringent figures up to 24 hours a day.

When the safety distances, which can be derived from the above safety levels with some assumptions of the antenna configurations used, have been agreed by the appropriate organisations they will be included in this report.

8. Conclusion

Extensive research has highlighted a potential compatibility problem between GSM transmitters and body worn audio apparatus; in particular hearing aids. However, this research has been based on a limited sample of hearing aid types of fairly old design.

An increased immunity for future body worn apparatus, enforced through the Community's EMC Directive (89/336/EEC), combined with some urban cellular design constraints aimed at ensuring the minimum transmit power is employed should ensure incidences of interference from GSM apparatus is kept to a minimum.

The studies made have shown that the immunity level of currently available hearing aids may not protect hearing aids very well from the interference of GSM phones. Also, it has been shown that increasing the immunity to 10 V/m, as found possible by simple hearing aid modification, will reduce the probability of interference considerably. More recent research has shown some modern hearing aids to have 10 times the immunity of the older designs (in V/m). This would reduce the interference probabilities by a factor of 100.

Concerning the domestic equipments it can be concluded that GSM transportable 8 W mobile stations are likely to cause problems to domestic equipment being used in a domestic environment.

Further, it is recommended that the user's data (like user's manual) of the mobile should include a warning of the possibe interference effects of the GSM mobile to the other electronic equipments.

9. Other EMC reports

CEPT-SE report — "Summary document on the interference to radio and non-radio devices from TDMA-type transmissions"
The report from CEPT covers much of the work included in the GSM report and considers EMC susceptibility of a far greater range of products. The findings of the two reports are similar.

CEPT-SE report — "Draft report from the ERC within CEPT on the impact from ISM emissions on mobile radio services operating in the 900 MHz band"
This report studies the potential for interference on GSM and other terminal equipment operating in the 900 MHz band caused by ISM equipment (*Industrial, Scientific and Medical*). It shows that spurious emissions from ISM equipment can degrade mobile radio service coverage at considerable distances.

ETSI/RES9 pr-IETS — "EMC standard for Radio Communication equipment and ancillary products."
This standard defines performance requirements for radio communication equipment to meet the Community directive 89/336/EEC. It contains requirements for GSM terminal equipment but does not address the potential of interference with other electronic equipment such as hearing aids and cardiac pace-makers.

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Annex A: A GSM interference model

A GSM interference model.

22nd February 1990

Jon Short
Cellular Radio Systems
BT Laboratories
0473 643954

Summary.

This document attempts to forecast the likely extent of interference to hearing aid users from GSM transmitters.

The assessment is made through modelling of the GSM cellular system in various scenarios as the system matures from 1991 onwards. The potential interference in the individual scenarios is combined to asses the actual interference perceived by through modelling of 'days in the life of' hearing aid users.

The critical inputs to the model are the hearing aid immunities as determined during extensive laboratory testing.

The report concludes that a hearing aid user will experience regular daily interference from GSM transmissions and this has been previously shown to be due to the TDMA nature of the system.

Contents